

WHAT IS CLAIMED IS:

1. A partly-finished product, in particular in the form of a foam sheet material, comprising destructured or complexed starch foamed as a continuous phase, having a density lying between 20 and 150 kg/m<sup>3</sup>, cell dimensions in a range lying between 25 and 700 µm with a cell distribution such that 80% of them have, in the absence of stretching, a dimension lying between 20 and 400 µm.
2. A partly-finished product, in particular in the form of a foam sheet material, according to claim 1 having a density lying between 25 and 100 kg/m<sup>3</sup> and cell dimensions in a range lying between 40 and 600 µm and with a cell distribution such that 80% of them have, in the absence of stretching, a dimension lying between 25 and 300 µm.
3. A partly-finished product, in particular in the form of a foam sheet material, according to claim 2 having a density lying between 30 and 70 kg/m<sup>3</sup> and with a cell distribution such that 80% of them have, in the absence of stretching, a dimension lying between 30 and 200 µm.
4. A partly-finished product, in particular in the form of foam sheet, according to claim 3 having a density lying between 30 and 70 kg/m<sup>3</sup> and average cell dimensions lying between 80 and 120 µm.
5. A partly-finished product according to any of claims 1 to 4, in which the starch is natural or modified starch or a mixture of these.

6. A partly-finished product according to claim 5 in which the natural or modified starch is derived from potato, wheat, maize and tapioca.

7. A partly-finished product according to claim 5 wherein the modified starch is physically or chemically modified, particularly ethoxylated starches, acetate starches, butyrate starches, propionate starches, hydroxypropylated starches, cationic starches, oxidated starches, cross-linked starches, gelatinised starches, starches complexed with molecules and/or polymers able to give "V" type complexes, dextrinated starches and starches grafted with chains such as polyesters, polyurethanes, polyesters-urethanes, polyureas, polyesters-ureas, polysiloxanes, silanes, titanates, fat chains.

8. A partly-finished product according to any of claims 1 to 7, able to form products with hinges obtained in a forming phase capable of resisting at least ten consecutive opening/closing cycles at 35% RH and 23°C without breaking, by using 2 - 4 seconds for each opening and closing operation.

9. A partly-finished product according to any of claims 1 to 8, in which the material from which the foam sheet is made has an intrinsic viscosity in DMSO at 30°C lying between 1.5 and 0.3 dl/g.

10. A partly-finished product according claims 9 in which the intrinsic viscosity in DMSO at 30°C is lying between 1.2 and 0.4 dl/g.

11. A partly-finished product according to claim 10, in which the intrinsic viscosity in DMSO at 30°C is lying between 1.1 and 0.6 dl/g.
12. A partly-finished product according to any of claims from 1 to 11, containing one or more thermoplastic polymers with a melting point lying between 60 and 175°C.
13. A partly-finished product according to claim 12 in which the thermoplastic polymer is a polymer of natural origin which can be modified or non modified, in particular derived from cellulose as cellulose acetate, cellulose propionate, cellulose butyrate and their co-polymers, with a degree of substitution lying between 1 and 2.5; polymers of the alkyl cellulose, hydroxy alkyl cellulose, carboxy alkyl cellulose type, in particular carboxy methyl cellulose, nitrocellulose and chitosan pullulan or casein and casinate, zein, soya protein, alginic acid and alginates, natural rubbers, polyaspartates; glutens, dextrens.
14. A partly-finished product according to claim 12 in which the thermoplastic polymer is a biodegradable polymers of synthetic or fermentative origin, in particular polyesters of the type including polymers or co-polymers of C<sub>2</sub>-C<sub>24</sub> aliphatic hydroxy acids, or their corresponding lactones or lactides, in particular polymers of lactic acid having various D/L lactic acid ratios, co-polymers of polylactic acid with aliphatic and aliphatic-aromatic polyesters, polycaprolactone, polyvalerolactone, their co-polymers and also polyesters derived from difunctional acids and aliphatic diols, aliphatic-aromatic polyesters, in particular co-polymers of the type including alkaline-terephthalate adipate treated or not with chain extenders, preferably with

quantities of tereftalic acid less than forty mole percent, epoxy resin in general and bisphenolic resin in particular.

15. A partly-finished product according to claim 12 in which the thermoplastic polymer is a polymer containing hydrophilic groups intercalated in hydrophobic sequences such as, for example, ethylene-vinylalcohol co-polymers, ethylene vinylacetate co-polymers, acrylic esters, acrylic ethylene-ester co-polymers, co-polymers of ethylene with unsaturated acids such as acrylic acid, methacrylic acid, crotonic acid, itaconic acid, co-polymers with hydrophilic units with a functional alcoholic a carboxylic group in aliphatic polyesters and/or aromatic-aliphatic polyesters, epoxy resins including resins containing bisphenols.

16. A partly-finished product according to claim 12 in which the thermoplastic polymer is a polymer able to form hydrogen bonds with the starch, in particular polyvinyl alcohol with various degrees of hydrolysis, possibly modified with acrylates or methacrylates, polyvinyl alcohol preliminarily plastisized or modified for the purpose of lowering its melting point.

17. A partly-finished product according to Claim 12 containing polymers such as polyvinylalcohol, copolymers of an olefin polymer, preferably ethylene, with a monomer chosen from vinyl alcohol, vinyl acetate, acrylic acid and methacrylic acid, aliphatic polyesters such as caprolactone, the polyalkylene succinates, the polymers of azelaic acid, sebacic acid brassilic acid and their co-polymers, aliphatic polyamides, polyalkylenesebacates, polyalkylene-azelates, polyalkylenebrassilates, in particular with diols comprised between C<sub>2</sub>-C<sub>13</sub>, polyesters containing dimeric acids, aromatic-

aliphatic polymers of the polyalkylene terephthalate adipate type and the epoxy resins, particularly with bisphenolic groups.

18. Partly-finished products according to any of Claims from 1 to 17, containing nucleating agents for the starting composition in concentrations lying in the range from 0.05 to 10% by weight, preferably between 0.5 and 7% and more preferably between 1 and 5%.

19. A partly-finished product according to Claim 18, in which the nucleating agent is constituted by inorganic compositions such as talc (magnesium silicate), calcium carbonate, sulphates of sodium and barium, titanium dioxide, possibly surface treated with adhesion promoters such as silanes, titanates.

20. A partly-finished product according to any of Claims from 1 to 19 containing organic fillers and fibres such as wood powder, cellulose, grape residue powder, bran, maize husks or other natural fibres in concentrations between 0.5 and 20%.

21. A partly-finished product according to any of Claims from 1 to 20, containing nucleating agents, lubricants and/or dispersants and plasticisers.

22. A partly-finished product according to any of Claims from 1 to 21 containing alimentary oils such as palm oil, maize oil, soya oil, sunflower oil,  $C_{12}$  to  $C_{22}$  fatty acids, their glycerides with various degrees of substitution, and in particular hydrogenated fats of animal or synthetic origin which are solid at least at ambient temperatures, and

preferably above ambient temperatures, to improve the moisture resistance and reduce the wetability by water.

23. A partly-finished product according to any of Claims from 1 to 22 containing weak acids such as lactic acid, tartaric acid, citric acid to regulate the viscosity of the starch during the extrusion process.

24. Products and partly-finished products obtained from the partly-finished products of Claims 1 to 23, obtained by lamination with layers of non-woven fabric, woven fabric, paper, biodegradable and non-biodegradable films or aluminium.

25. Products and partly-finished products according to claim 24 produced by lamination with non-woven fabric or woven fabric of natural fibres, such as for example fibres of jute, cotton, wool, fibre based on polysaccharides such as, for example, cellulose acetate, starch acetate, viscose etc, or fibres produced starting from biodegradable polymers and in particular aliphatic polyesters such as polylactic acid, polycaprolactone, polyalkaline carboxylates with die alcohols and die acids selected from the linear range  $C_2-C_{13}$  and/or cycloaliphatic, aliphatic-aromatic polyesters, in particular from the family of adipated terraphelate polyalkalines and their co-polymers, polyamides, in particular based on caprolactane, aliphatic amine etc, aliphatic polyurethanes, polyester-urethanes, polyurea, and epoxy resins.

26. Products and partly-finished products according to claim 24 coupled with films constituted by biodegradable polymers and in particular aliphatic polyesters such as polylactic acid, polycaprolactone and/or cycloaliphatics, polyalkaline

carboxylates with dialcohols and diacids selected from the linear range  $C_2$ ,  $C_{13}$ , aliphatic-aromatic polyesters, in particular from the family of adipated terephthalate polyalkylenes and their co-polymers, polyamides, in particular based on caprolactam, aliphatic amines etc, aliphatic polyurethanes, polyester-urethanes, polyureas, epoxy resins obtained by blown extrusion, co-extrusion and/or casting.

27. Products and partly-finished products obtained from the partly-finished products of Claims from 1 to 23, by way of coating with emulsions, dispersions, solutions, hot melts of biodegradable polymers and in particular aliphatic polyesters such as polylactic acid, polycaprolactone, polyalkylene carboxylates with dialcohols and diacids selected from the linear and/or cycloaliphatics range  $C_2$ - $C_{13}$ , aliphatic-aromatic polyesters, in particular from the family of adipated polyalbylene terephthalates and their co-polymers, polyamides, in particular based on caprolactane, aliphatic amines etc, aliphatic polyurethanes, polyester-urethanes, polyureas, epoxy resins.

28. Products and partly-finished products according to Claim 26, in which the films are coupled to the partly-finished products by temperature and/or the application of suitable biodegradable adhesives based on polymers of lactic acid, polyurethanes, polyvinylactates and polyvinylalcohols, proteins such as casein and gluten, starches, dextrans and other polysaccharides.

29. Products and partly-finished products according to Claims 26 and 28, in which the films can be obtained from

cast and bubble film-forming and can be co-extruded with an adhesive surface for the foamed support.

30. Products and partly-finished products according to Claim 29, in which the films have a melting point greater than 60°C, preferably greater than 80°C and more preferably greater than 100°C.

31. A sheet according to Claim 26 or Claim 28 form able as a non-laminated sheet.

32. Products and partly-finished products obtained from the materials of Claims 1 to 23, treated with natural and synthetic waxes with melting points up to 120°C in depending on their various applications.

33. A process for the production of foam sheet by extruder comprising the steps of:

- supplying to an extruder starch with an intrinsic viscosity lying between 2 and 0.6 dl/g in the presence of water in proportions from 6 to 30% by weight of the total composition, in quantities such as to permit the starchy component constitute the continuous phase of the material, possibly a natural or synthetic thermoplastic polymer and further additives such as plasticisers, lubricants, nucleating agents, surfactants, weak acids and fillers.

- complete melting of the starchy mass

- introduction of CO<sub>2</sub> in quantities lying between 0.4 and 10%, preferably between 0.8 and 7% and more preferably between 1.0 and 4% by weight into the melt at a temperature lying between 100 and 180°C, preferably between 120 and 160°C; and



- working the melt for between 5 and 40 minutes to homogenise the distribution of the mixture of expanding agents, water and  $\text{CO}_2$  and, possibly, chemical expanding agents such as citric acid and bicarbonate, and to adjust the viscosity of the composition to between 1.5 and 0.3 dl/g.

34. A process according to Claim 33 in which the extrusion of the melt takes place through a flat or tubular head able to impart to the melt shear rates comprised between 500 and 50,000  $\text{sec}^{-1}$  preferably between 800 and 40,000  $\text{sec}^{-1}$  and more preferably between 900 and 35,000  $\text{sec}^{-1}$ .

35. A process according to Claim 34 in which the extruded tubular sheet is blown with air or steam to impart by biaxial stretch, confer smooth surfaces and hold the sheet at the desired moisture point, opened, calendered, possibly further conditioned and wound on a coil.

36. A process according to Claim 34 in which the tubular sheet is blown with air or steam to distend the sheet itself and hold it at the desired moisture point, opened calendered and cut into flat sheets.

37. A process according Claim 34, in which there is produced a partly-finished product in the form of a tube which is calibrated, conditioned and then collected.

38. A process for forming partly-finished products according to any of Claims from 1 to 32 which comprises:

- conditioning the product or partly-finished product to a water content between 6% and 30% preferably between 10% and 25% and more preferably between 15% and 20% and at a

temperature between 40 and 120 °C and preferably between 40 and 100° C,

- forming in a male-female impact mould between ambient temperature and 80° C
- possible creasing to provide a product formed with a density between 40 and 400 kg/m<sup>3</sup> preferably between 45 and 200 kg/m<sup>3</sup> and more preferably between 50 and 150 kg/m<sup>3</sup> possibly having a hinge resistant to repeated closure/opening cycles.

39. Combinations of partly finished product according to any of the Claims 1-32 in multilayer structures to form products of various geometry such as rolls, blocks and foam sheet of significant resilience, corner pieces, protective containers for use in the electrical domestic appliance sectors, or for electronic products, in the food sector, for pharmaceuticals, for design and furniture, for mail order or envelopes for couriers.

40. Combinations of materials according to Claims 1 to 32, with other supports to provide multilayers mixed with wood, paper, cardboard, non-woven fabric, woven fabric of natural or synthetic fibres, aluminium or other metals for use in the packaging sector.

41. Products formed according to Claim 38, used principally in the food packaging sector and in particular as trays for foods with a lifetime of the order of 30 days for packaging meat, dairy products, vegetables, eggs, fruit; display containers for glass, plastic or metal packages of small dimensions, containers for fast food such as containers for hamburgers, potato chips and similar products; multi compartment containers for fast food and meals.

42. Products formed according to Claim 38, used for hot and cold liquids as cups for coffee and drinks, containers for soup of the type used in Asiatic countries and for other products having a high liquid content for fast food and meals.

43. Products formed according to Claim 38, used as containers for objects of small weight such as multi-compartment trays for portable telephones and small electrical domestic appliances, in particular, with mechanical properties such as to avoid phenomena of abrasion encountered with containers of pressed paper etc.

44. Products according to Claim 38, in the form of trays for wrapping meat in supermarkets which provide for the use of absorbent or super absorbent materials for eliminating the presence of blood, fitted directly into the sheet, applied to the surface or in intermediate layers between two shells welded together or under the film which renders the tray impermeable.

45. Products formed according to Claim 38, in the form of containers for oven and microwave use possibly surface treated to avoid excessive weakening of the container by the effect of the removal of the water.